THE AQUATIC PLANT COMMUNITY FOR LOWER CAMELOT LAKE
ADAMS COUNTY 2006

I. INTRODUCTION

An updated aquatic macrophytes (plants) field study of Lower Camelot Lake was conducted during August 2006 by a staff member the Adams County Land and Water Conservatism Department and a staff member of the Tri-Lakes Management District. The first quantitative vegetation study was performed by Wisconsin Department of Natural Resources staff in 2000.

Information about the diversity, density and distribution of aquatic plants is an essential component in understanding the lake ecosystem due to the integral ecological role of aquatic vegetation in the lake and the ability of vegetation to impact water quality (Dennison et al, 1993). This study will provide information useful for effective management of Lower Camelot Lake, including fish habitat improvement, protection of sensitive areas, aquatic plant management, and water resource regulation. This data will be compared to the past and future studies and offer insight into changes in the lake.

Ecological Role: Lake plant life is the beginning of the lake's food chain, the foundation for all other lake life. Aquatic plants and algae provide food and oxygen for fish and wildlife, as well as cover and food for the invertebrates that many aquatic organisms depend on. Plants provide habitat and protective cover for aquatic animals. They also improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake, and impact recreation.

Characterization of Water Quality: Aquatic plants can serve as indicators of water quality because of their sensitivity to water quality parameters such as clarity and nutrient levels (Dennison et al, 1993).

Testing has shown that Lower Camelot Lake has very hard water. Lake water pH has ranged from 6.3 to 8.21. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes.

Background and History: Lower Camelot Lake is located in the Town of Rome, Adams County, Wisconsin. The impoundment is slightly over 200 surface acres in size. Maximum depth is 24', with an average depth of 8'. During the summer of 2006 when this aquatic plant survey was conducted, the lake was at slightly lower level than usual due to drought and very hot weather. The dam impounds Fourteen-Mile Creek downstream upstream from Arrowhead Lake and Sherwood Lake, on its way to the Wisconsin River. There is a public boat ramp located on southwest side of the lake owned by The Adams County Parks Department.

Lower Camelot Lake is accessible off of State Highway 13 by turning east onto either Apache Avenue, then north on 10th Avenue to the County Park entrance. Heavy residential development around the lake is found along most of the lakeshore. The surface watershed is 39.88% residential; 30.06% woodlands; 11.66% outdoor recreation (mostly golf courses); 9.82% water; 4.9% industrial/commercial/governmental; and 3.68% open grassland. The ground watershed, which extends into Waushara County, has much irrigated and non-irrigated agriculture, except near to the lakes. There are endangered or threatened resources in the watershed including the Karner Blue Butterfly, the Greater Prairie Chicken; the Long-Leaf Aster; and the natural communities of northern dry-mesic forest and alder thicket. Archeological sites reported in the Lower Camelot Lake surface watershed include an unnamed burial site in Adams County, as well as the Millard Smith Mound Group, Lake Huron Group, Krushki Group, Town House Mounds, and Weymouth Group, all located in Waushara County.

A fishery inventory in October 2004 revealed that bluegills and largemouth bass are abundant in Lower Camelot Lake, although bluegills had a poor size (stunted growth) structure; all other fish found, including black crappie, northern pike, pumpkinseed, yellow perch, and walleye, were scarce. In the 1970s, the lake was stocked with largemouth bass, walleye, northern pike and bluegills.

Soils in the Lower Camelot Lake surface watershed are sands of various slopes. Such soils tend to be excessively-drained, with infiltration of water being rapid to very rapid, and permeability also high. Such soils also usually have a low water-holding and low organic matter content, thus making them difficult to establish vegetation on. These soils tend to be easily eroded by both water and wind.

Efforts at controlling aquatic plant growth have included both chemical treatments and mechanical harvesting.

Year	Copper	Cutrine+	Aquathol	Hydrothol	Diquat	Rodeo	2,4-D	Silvex	AV-70
_	(lbs)	(gal)	(gal)	(gal)	(gal)	(gal)	(lbs)	_	_
1970	400		5		10			2	
1971	85		5		29.5			13	
1972	105				8				
1973	985				29.5				
1974	380				23				
1975	374		16.5		13				14
1976	130		70	100	16				17
1977	520		25	400	10		14		10.5
1978									
1979	400								
1980	250								
1984				30					
1985	75		26		5				
1986	265		24		4				
1987	210								
1988	1085				20				
1989	1000		15		10				
1990	270		15		21	6	10		
1991	375		12.5		4		10		
1992	350		20		12				
1993	200				15		10		
1994	150		38.25		22.75		10		
1995	355		52		21.75		10		
1996		32	15		15		10		
1997		46.5	3		3				
1999			5		5				
2000					30				
total	**7967**	**78.5**	**362.25**	**530**	**327.5**	**6**	**74**	**19**	**41.5**

Both copper in pounds and cutrine in gallons added copper to Lower Camelot Lake. Copper is an element and does not degrade any further. Copper is known to harm native mollusks (clams, mussels, snails) and invertebrates that serve as food for the fish. Hydrothol, added to Lower Camelot Lake between 1977 and 1984, has been implicated in damage to young fish.

Mechanical harvesting of aquatic plants in Lower Camelot Lake started in 1995 and has continued through 2006. The chart below shows the pounds of aquatic plant removed through mechanical harvesting through 2006. For 2005 and 2006, plant samples were taken to a laboratory to be tested for the amount of phosphorus in milligrams per kilogram of aquatic plants. This is also shown on the chart below.

Year	Lake Camelot (lbs)	Lower Camelot (lbs)	Phosphorus Removed (lbs)
1995	153,000		NA
1996	139,600		NA
1997	152,000		NA
1998	292,000		NA
1999		307,600	NA
2000		276,000	NA
2001		376,600	NA
2002		453,000	NA
2003		453,000	NA
2004		338,000	NA
2005		911,400	2413.39
2006		607,000	871.65
total	736,600	3,722,600	3,285

An aquatic plant survey was by WDNR staff in 2000. This survey found that that the plant-like algae, *Chara* spp (muskgrass), was the most frequently-occurring aquatic "plant" species in Lower Camelot Lake, followed by *Myriophyllum* spicatum (Eurasian watermilfoil) and *Potamogeton pusillus* (small pondweed). Only *Chara* spp. occurred at more than 50% frequency. *Chara* spp also had the highest density. On the lake overall, no aquatic species occurred at more than average density, although *Chara* spp., *Elodea canadensis, Najas flexilis,* and *Typha latifolia* occurred at more than average density where they were present. Although three invasives, *Myriophyllum spicatum* (Eurasian watermilfoil), *Phalaris arundinacea* (Reed Canarygrass), and *Potamogeton crispus* (Curly-Leaf Pondweed) were found in 2000, none of them occurred at high frequency, density or dominance.

Since the discovery of zebra mussels in Arrowhead Lake, the WDNR has been monitoring Lower Camelot Lake for any sign of infestation. As of 2006, no zebra mussels had been found in Lower Camelot Lake.

II. METHODS

Field Methods

The 2000 and 2006 studies used the same transects and were both based on the rake-sampling method developed by Jessen and Lound (1962), using stratified random transects. The shoreline was divided into 19 equal sections, with one transect placed randomly within each segment, perpendicular to the shoreline.

One sampling site was randomly located in each depth zone (0-1.5'; 1.5'-5'; 5'-10'; 10'-20') along each transect. Using long-handled, steel thatching rakes, four rake samples were taken at each site. Samples were taken from each quarter around the boat. Aquatic species present on each rake were recorded and given a density rating of 0-5.

A rating of 1 indicates the species was present on 1 rake sample.
A rating of 2 indicates the species was present on 2 rake samples.
A rating of 3 indicates the species was present on 3 rake samples.
A rating of 4 indicates the species was present on 4 rake samples.
A rating of 5 indicates that the species was abundantly present on all rake samples.

A visual inspection and periodic samples were taken between transects to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording species found.

Shoreline type was also recorded at each transect. Visual inspection was made of 50' to the right and left of the boat along the shoreline, 35' back from the shore (so total view was 100' x 35'). Percent of land use within this rectangle was visually estimated and recorded.

Data Analysis:

The percent frequency (number of sampling sites at which it occurred/total number of sampling sites) of each species was calculated. Relative frequency (number of species occurrences/total of all species occurrences) was also calculated. The mean density (sum of species' density rating/number of sampling sites) was calculated for each species. Relative density (sum of species' density/total plant density) was also calculated. "Mean density where present "(sum of species' density rating/number of sampling sites at which species occurred) was calculated. Relative frequency and relative density results were summed to obtain a dominance value. Species diversity was measured by Simpson's Diversity Index.

The Average Coefficient of Conservatism and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance. A coefficient of Conservatism is an assigned value between 0 and 10 that measures the probability that the species will occur in an undisturbed habitat. The Average Coefficient of Conservatism is the mean of the coefficients for the species found in the lake. The coefficient of conservatism is used to calculate the Floristic Quality Index, a measure of a plant community's closeness to an undisturbed condition.

To measure the quality of the aquatic plant community, an Aquatic Macrophyte Index was determined using the method developed by Nichols et al (2000). This measurement looks at the following seven parameters and assigns each of them a number on a scale of 1-10: maximum depth of plant growth; percentage of littoral zone vegetated; Simpson's diversity index; relative frequency of submersed species; relative frequency of sensitive species; taxa number; and relative frequency of exotic species. The average total for the North Central Hardwoods lakes and impoundments is between 48 and 57.

III. RESULTS

Physical Data

The aquatic plant community can be impacted by several physical parameters. Water quality, including nutrients, algae and clarity, influence the plant community; the plant community in turn can modify these boundaries. Lake morphology, sediment composition and shoreline use also affect the plant community.

The trophic state of a lake is a classification of water quality (see Table 1). Phosphorus concentration, chlorophyll a concentration and water clarity data are collected and combined to determine a trophic state. **Eutrophic lakes** are very productive, with high nutrient levels and large biomass presence. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small fisheries. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; those with a good and more varied fishery than either the eutrophic or oligotrophic lakes.

The limiting factor in most Wisconsin lakes, including Lower Camelot Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. **The 2004-2006 summer average phosphorus concentration in Lower Camelot Lake was 29.735 ug/ml.** This is very close to average for impoundments (30.0 mg/l). This concentration suggests that Lower Camelot Lake is likely to have some nuisance algal blooms, but not as frequently as many impoundments. This places Lower Camelot Lake in the "good" water quality section for impoundments, and in the "**mesotrophic**" level for phosphorus.

Chlorophyll a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth. **The 2004-2006 summer average chlorophyll a concentration in Lower Camelot Lake was 19.61 ug/ml.** These chlorophyll a results place Lower Camelot Lake at the "**eutrophic**" level with "poor" water quality.

Water clarity is a critical factor for plants. If aquatic plants receive less than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. **Average summer Secchi disk clarity in Lower Camelot Lake in 2004-**

2006 was 5.525'. This is fair water clarity, putting Lower Camelot Lake into the "**mesotrophic**" category for water clarity.

It is normal for all of these values to fluctuate during a growing season. They can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Phosphorus tends to rise in early summer, than decline as late summer and fall progress. Chlorophyll a tends to rise in level as the water warms, then decline as autumn cools the water. Water clarity also tends to decrease as summer progresses, probably due to algae growth, then improve as fall approaches.

Table 1: Trophic States

Trophic State	Quality Index	Phosphorus (ugm/l)	Chlorophyll a (ug/ml)	Sechhi Disk (ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	1 to 5	8 to 19
Mesotrophic	Good	**10 to 30**	5 to 10	6 to 8
	Fair	30 to 50	10 to 15	**5 to 6**
Eutrophic	Poor	50 to 150	**15 to 30**	3 to 4
Lower Camelot Lake		**29.735**	**19.61**	**5.25'**

According to these results, Lower Camelot Lake scores as **"eutrophic"** in two of the three general parameters often used to gauge lake water health and **"mesotrophic"** in phosphorus readings. With such phosphorus readings, moderate plant growth would be expected. With such cholorophyll a readings, more than occasional algal blooms would be expected.

A groundwater study done in 2000 by UW-Stevens Point staff found that the groundwater coming into Lower Camelot Lake showed elevated chloride & reactive phosphorus levels, along with elevated nitrate or ammonium, suggesting nutrient inputs from septic systems. A limnological investigation performed by the U.S. Army Corps of Engineers in 2000 indicated that Lower Camelot Lake had a significant increase of phosphorus from sediments under anoxic conditions. These studies indicated that internal phosphorus loading is probably occurring in Lower Camelot Lake, which increases the likelihood of aquatic plant growth and algae occurrence.

Lake morphology is an important factor in distribution of lake plants. Duarte & Kalff (1986) determined that the slope of a littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support higher plant growth than steep slopes (Engel 1985).

Lower Camelot Lake is a narrow lake that lies at the beginning of a series of lakes that are originally fed by a very large, multi-county stream system. Much of the lake is shallow, although there are some areas of steeper drop-offs within the lake near the dam. With fair water clarity and shallow depths, plant growth may be favored in much of Lower Camelot Lake, since the sun reaches much of the sediment to stimulate plant growth.

Sediment composition can also affect plant growth, especially those rooted. The richness or sterility and texture of the sediment will determine the type and abundance of macrophyte species that can survive in a particular location.

Table 2: Sediment Composition—Lower Camelot Lake

Sediment	Type	Zone 1	Zone 2	Zone 3	Zone 4	Overall
Hard	Sand	60.00%	75.00%	80.00%	100.00%	78.08%
	Sand/Rock	5.00%				1.37%
	Rock	15.00%				4.11%
Mixed	Sand/Muck	10.00%				2.74%
Soft	Muck	10.00%	15.00%			6.85%
	Peat		10.00%	20.00%		6.85%

Most of the sediment in Lower Camelot Lake is hard, with little natural fertility and low available water holding capacity. Although such sediment may limit growth, most hard sediment sites in Lower Camelot Lake were vegetated. 86.3% sample sites were vegetated in Lower Camelot Lake, no matter what the sediment. Most unvegetated sites appeared to have had vegetation cleared by hand harvesting.

Shoreline land use often strongly impacts the aquatic plant community and thus the entire aquatic community. Impacts can be caused by increased erosion and sedimentation and higher run-off of nutrients, fertilizers and toxins applied to the land. Such impacts occur in both rural and residential settings.

Natural vegetation covered only 23.0% of the lake shoreline. Naturally-occurring rock covered 2.5% of the shore. Disturbed shorelines—including bare sand, traditional cultivated lawn, hard structure (piers, decks, seawalls, etc.) and rock riprap--were the most frequently-occurring shore, with each occurring with 25% to 70% frequency. Overall, they covered 77.0% of the shore of Lower Camelot Lake.

Table 3: Shoreland Land Use—Lower Camelot Lake—2000 and 2006

		2006	2000	2006	2000
Natural		**Frequency**	**Frequency**	**Coverage**	**Coverage**
Vegetated	Herbaceous	60.00%	50.00%	16.5%	11.50%
Shoreline	Shrub	25.00%	25.00%	2.5%	6.75%
	Wooded	20.00%	5.00%	4.00%	50.00%
Disturbed	Bare Sand/Eroded	25.00%	60.00%	14.5%	25.75%
Shoreline	Cultivated Lawn	70.00%	70.00%	35.50%	47.75%
	Hard Structure	65.00%	25.00%	13.25%	1.50%
	Pavement	0%	10.00%	0%	2.25%
	Rock /riprap	65.00%	45.00%	13.75%	4.00%

Macrophyte Data

SPECIES PRESENT

Of the 23 species found in Lower Camelot Lake, 21 were native and 2 were exotic invasives. In the native plant category, 8 were emergent, 1 was a floating-leaf plant, and 12 were submergent species. Two exotic invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil) and *Phalaris arundinacea* (Reed Canarygrass) were found.

Comparing the species found in 2006 to those reported in 2000, some changes are evident. Plants found in 2000 that were not found in 2006 included: *Eleocharis acicularis* (emergent); *Lemna minor* (free-floating); and *Potamogeton crispus* (an invasive submergent). Several plants found in 2006 were not found in 2000: *Alisma gramineum* (emergent); *Carex* spp (emergent); *Impatiens capensis* (emergent); *Myriophyllum sibiricum* (submergent); *Potamogeton zosteriformis* (submergent); and *Salix spp* (emergent). Since the 2006 plant survey was conducted in August, past primary growing season for *Potamogeton crispus*, it is possible that *P. crispus* was present earlier in the summer in 2006, since it was found in 2000.

Table 4—Plants Found in Lower Camelot Lake, 2006

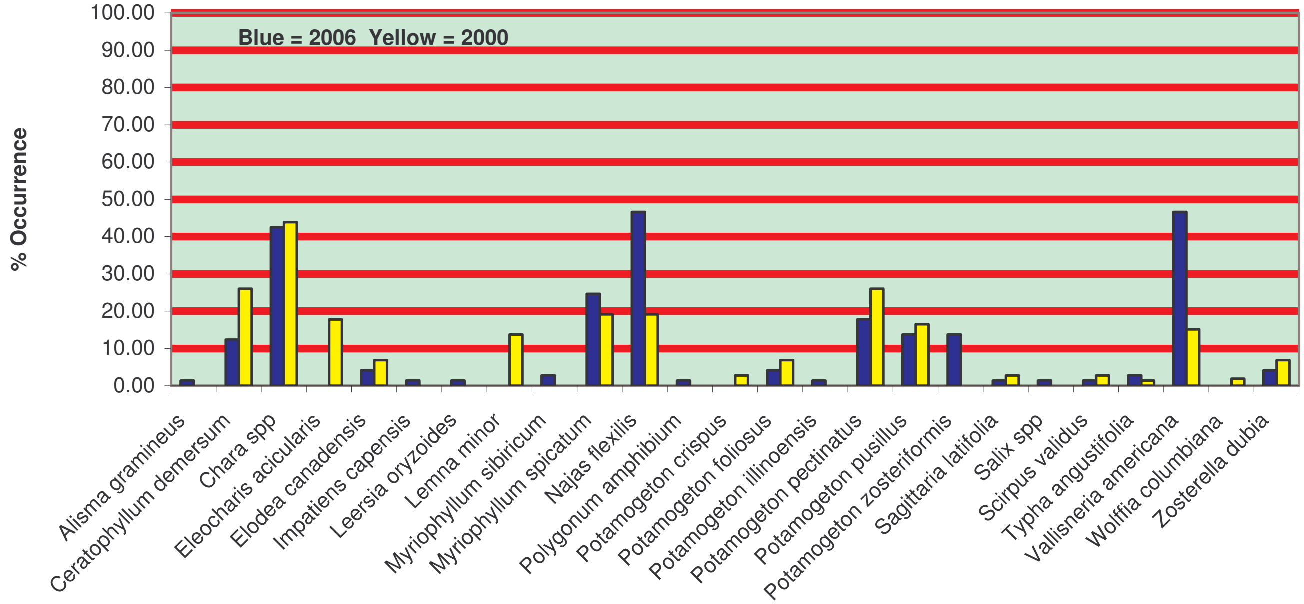
Scientific Name	Common Name	Type	Found in 2000
Alisma gramineus	Water Plantain	Emergent	
Carex spp	Sedge	Emergent	
Ceratophyllum demersum	Coontail	Submergent	x
Chara spp	Muskgrass	Submergent	x
Elodea canadensis	Waterweed	Submergent	x
Impatiens capensis	Jewelweed	Emergent	
Leersia oryzoides	Rice Cut-grass	Emergent	
Myriophyllum sibiricum	Northern Milfoil	Submergent	
Myriophyllum spicatum	Eurasian Watermilfoil	Submergent	x
Najas flexilis	Bushy Pondweed	Submergent	x
Phalaris arundinacea	Reed Canarygrass	Emergent	x
Polygonum amphibium	Water Smartweed	Floating Leaf	
Potamogeton foliosus	Leafy Pondweed	Submergent	x
Potamogeton illinoensis	Illinois Pondweed	Submergent	
Potamogeton pectinatus	Sage Pondweed	Submergent	x
Potamogeton pusillus	Small Pondweed	Submergent	x
Potamogeton zosteriformis	Flat-Stem Pondweed	Submergent	
Sagittaria latifolia	Lower Camelot	Emergent	x
Salix spp	Willow	Emergent	
Scirpus validus	Soft-Stem Bulrush	Emergent	x
Typha angustifolia	Narrow-Leaf Cattail	Emergent	x
Vallisneria americana	Water Celery	Submergent	x
Zosterella dubia	Water Stargrass	Submergent	x

Of the plants on this list, several are species likely to increase in frequency and/or density in the case of regular drawdowns: *Leersia oryzoides* (emergent); *Najas flexilis* (submergent); *Potamogeton crispus* (submergent exotic); *Potamogeton pectinatus* (submergent); *Scirpus validus* (emergent) and *Potamogeton zosteriformis* (submergent). Some also tend to decrease with regular drawdowns: *Chara* spp (submergent); *Myriophyllum sibiricum* (submergent); *Myriophyllum spicatum* (submergent exotic); and *Vallisneria americana* (submergent). In general, regular drawdowns will tend to encourage the increase of plants that can survive frequent disturbances and will also tend to reduce the diversity of the aquatic plant community.

FREQUENCY OF OCCURRENCE

Najas flexilis and *Vallisneria americana* were the most frequently-occurring plants in Lower Camelot Lake in 2006 (each with 46.58% frequency), closely followed by *Chara* spp at 42.47% occurrence frequency. In 2000, *Chara* spp. was the most-frequency occurring species. No species reached a frequency of 50% or greater in the lake overall in either 2000 or 2006. When reviewing the frequency where vegetated in 2006, only *Vallisneria americana* reached an occurrence frequency over 50%, and *Chara* spp was just under at 49.21%. The only species reaching an occurrence frequency over 50% where present in 2000 was *Chara* spp at 50.79%. Overall, the occurrence of *Chara* has not changed since 2000, but both *Najas flexilis* and *Vallisneria americana*, both plants that are very tolerant of disturbance, have increased dramatically since 2000. *Vallisneria americana* is also encouraged by harvesting.

Chart 1: Occurrence Frequency

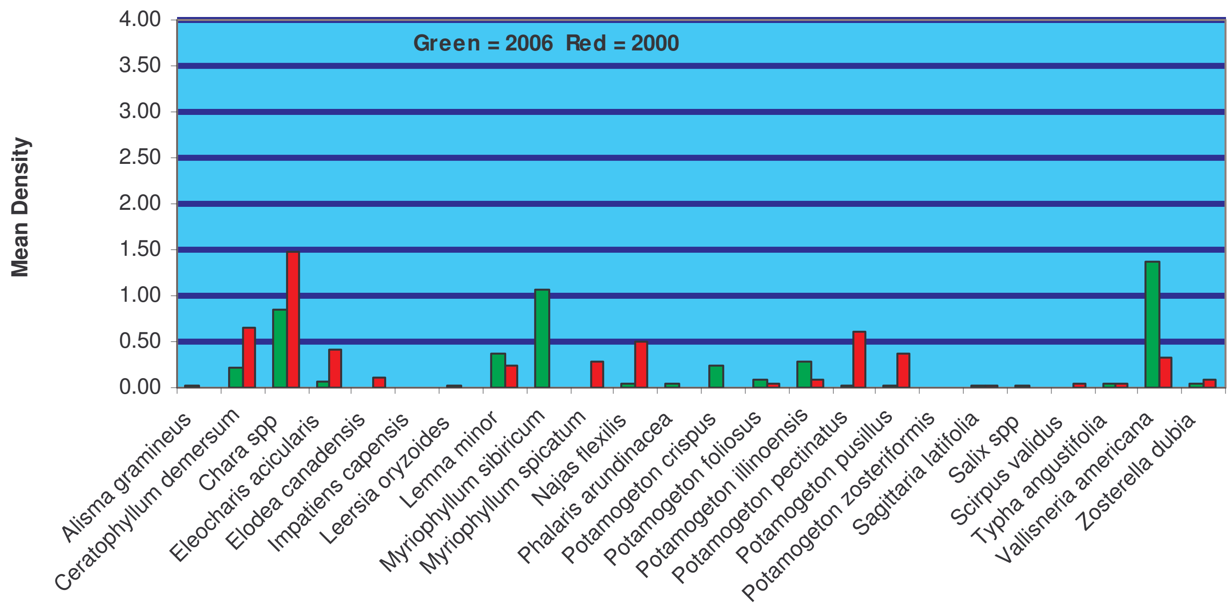


Filamentous algae were found at 8.22% of the sample sites in 2006 and at 16.44% of the sites in 2000.

DENSITY OF OCCURRENCE

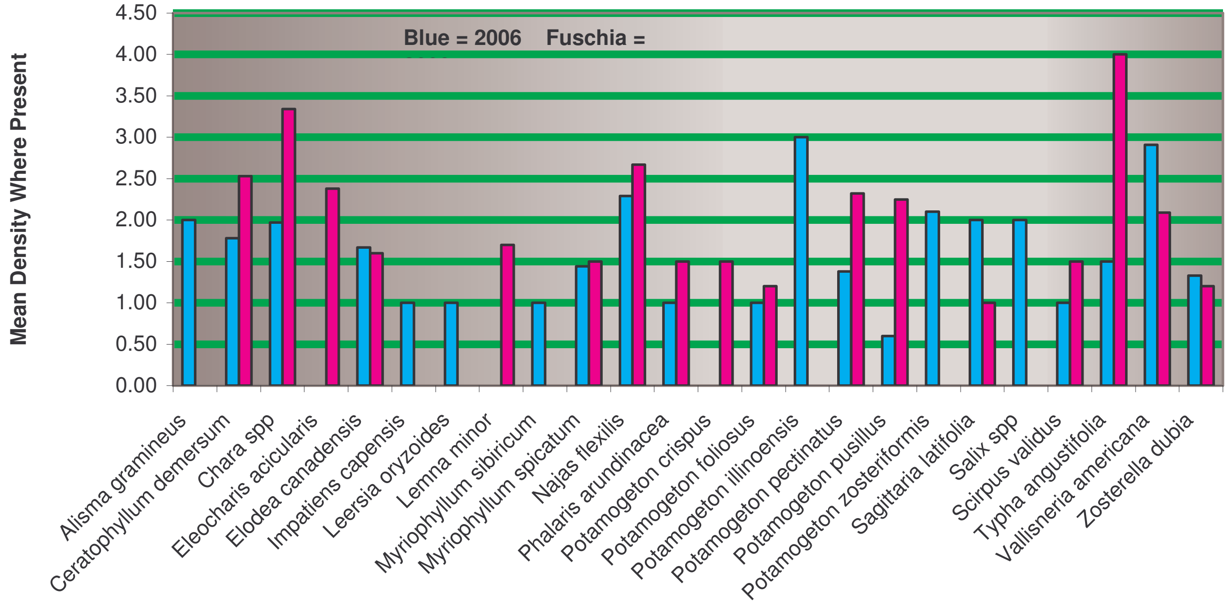
Vallisneria americana was also the densest plant in 2006 in Lower Camelot Lake, with a mean density of 1.36 (on a scale of 1 to 4). In the lake overall, none of the aquatic vegetation had a mean density of over 2.0, meaning none occurred at more than average density, in either 2000 or in 2006. In 2006, there were no species at more than average density in Depth Zones 1, 2 and 4. Zone 3 had *Vallisneria americana* at 2.42 density. The densest-occurring plant in Depth Zone 1 (0-1.5’) was *Najas flexilis* (1.3). Densest in Depth Zone 2 (1.5’-5.0’) was *Chara* spp (1.91). In Depth Zone 4 (10’-20’), *Vallisneria americana* was densest, with a density of 1.14.

Chart 2: Occurrence Density



However, when looking at the “mean density where presen”, several plants had a more than average density in 2006: *Najas flexilis; Potamogeton illinoensis; Potamogeton zosteriformis,* and *Vallisneria americana.* All of these plants are submergent plants. These figures indicate several species in the lake have higher than average growth form density that can interfere with fish habitat and recreational use.

Chart 2A: Density Where Present



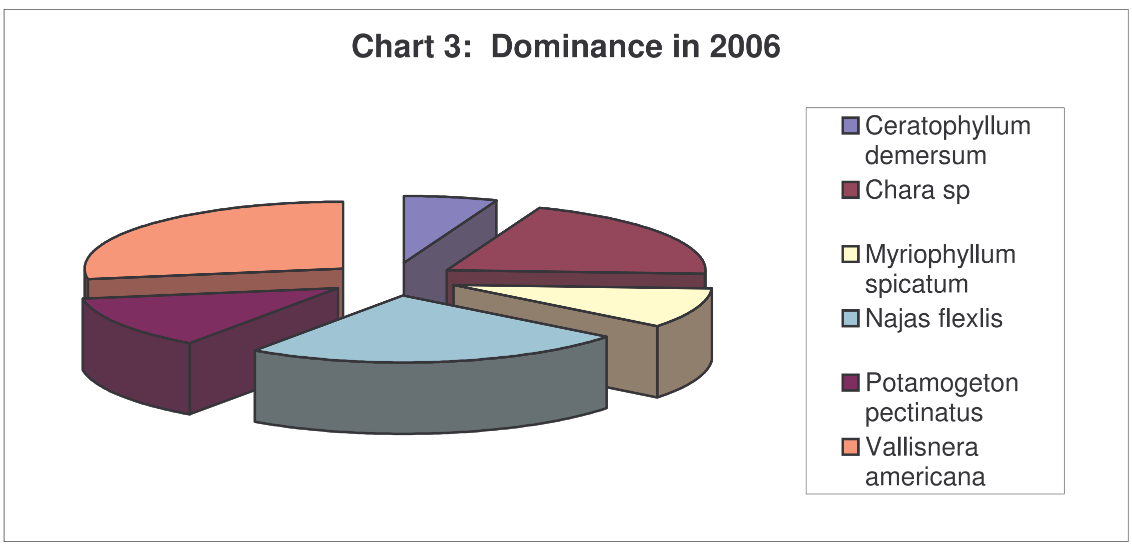
Several other plants found in 2006 are on the verge of more than average densities with "mean densities where present" of 2.00: *Alisma gramineus; Sagittaria latifolia; Salix* spp. All of these are emergent plants and occur rarely in Lower Camelot Lake.

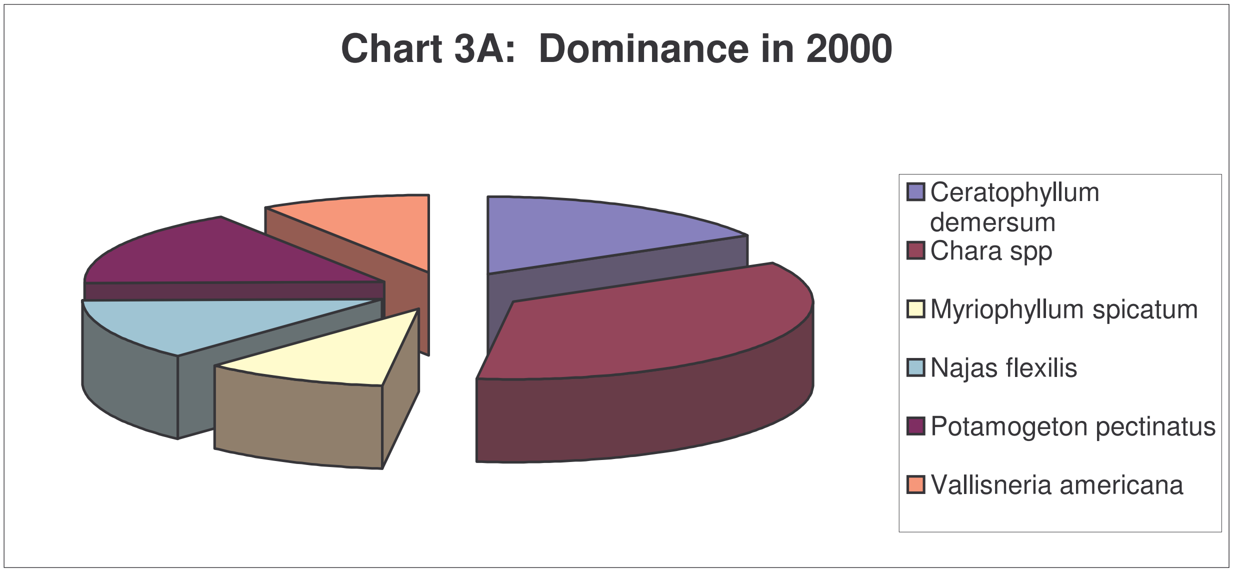
In 2000, more species occurred at more than average "density where present" than in 2006: *Ceratophyllum demersum; Chara spp; Eleocharis acicularis; Najas flexilis; Potamogeton pectinatus; Potamogeton pusillus; Typha angustifolia;* and *Vallisneria americana.* Only *Eleocharis acicularis* and *Typha angustifolia* are emergent plants; the rest are submergent plants.

DOMINANCE

Relative frequency and relative density are combined into a dominance value that demonstrates how dominant a species is within its aquatic plant community. Based on dominance value, *Vallisneria americana* was the dominant aquatic "plant" species in Lower Camelot Lake in 2006, followed closely by *Najas flexilis*. Sub-dominant were *Chara* spp. *Chara* spp dominated the aquatic plant community of Lower Camelot Lake in 2000. The next closest species was *Ceratophyllum demersum*, with half the dominance value of *Chara spp* in 2000.

Myriophyllum spicatum and *Phalaris arundinacea*, the exotics found Lower Camelot Lake, were not present in high frequency or high density, but *Myriophyllum spicatum* had substantial dominance in both years.





In 2006, *Chara* spp was dominant in Depth Zone 1, with *Najas flexilis* subdominant. *Chara* spp and *Vallisneria Americana* were co-dominant in Depth Zone 2, with *Najas flexilis* sub-dominant. *Vallisneria americana* was dominant in Depth Zone 3. *Chara* spp dominated Depth Zone 4.

DISTRIBUTION

Aquatic plants occurred at 86.3% of the sample sites in Lower Camelot Lake to a maximum rooting depth of 15.5'. The same aquatic plant occurrence (86.3%) was found in 2000, but the maximum rooting depth then was only 13'. Free-floating plants were found in the first three depth zones in both years. Filamentous algae were found in all sampling zones in 2006, but only in the two shallowest zones in 2000.

Secchi disc readings are used to predict maximum rooting depth for plants in a lake (Dunst, 1982). Based on the summer 2004-2006 Secchi disc readings, the predicted maximum rooting depth in Lower Camelot Lake would be **9.47 feet.** During the 2006 aquatic plant survey, rooted plants were found at a depth of **15.5'**, i.e., rooted plants were at a depth substantially more than that to be expected by Dunst calculations.

In 2006, the 1.5'-5' depth zone (Zone 2) produced the highest total occurrence of plant growth, followed by Depth Zone 1 and Depth Zone 3 (which tied), then a sharp drop to occurrence frequency in Depth Zone 4. The pattern was different in 2000: Depth Zone 3 had the highest occurrence frequency, then a drop in frequency in Depth Zone 2, with another drop to Zone 4, then Zone 1 being close to Zone 4, but having the least occurrence frequency. This shift may be due to the harvesting of waters less than 6' deep.

For total plant density in 2006, Depth Zone 2 had the most total density, and Depth Zone 3 had denser growth than Depth Zone 1. Another sharp drop in density characterized Depth Zone 4. In 2000, Depth Zone 3 had the highest total density, followed by Zone 2. One-half of the density of Zone 2 characterized Zone 1, then another drop in density in Zone 4. This drop in density may also be connected to the changed harvesting plan.

Chart 4: Zone Occurrence

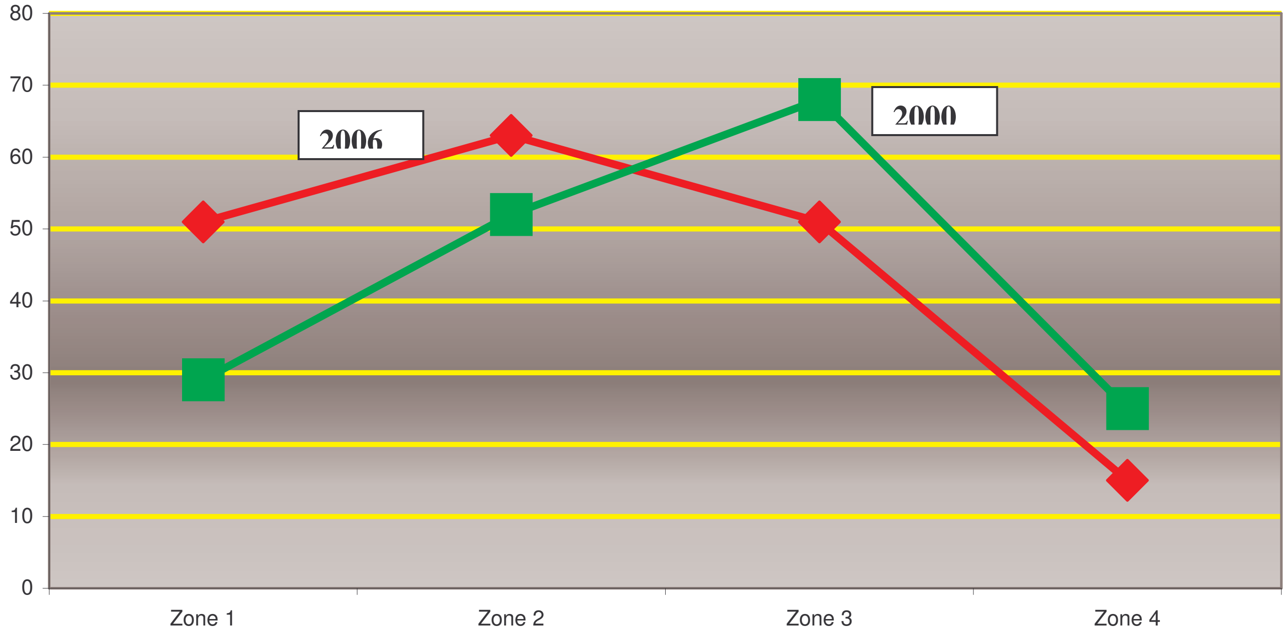
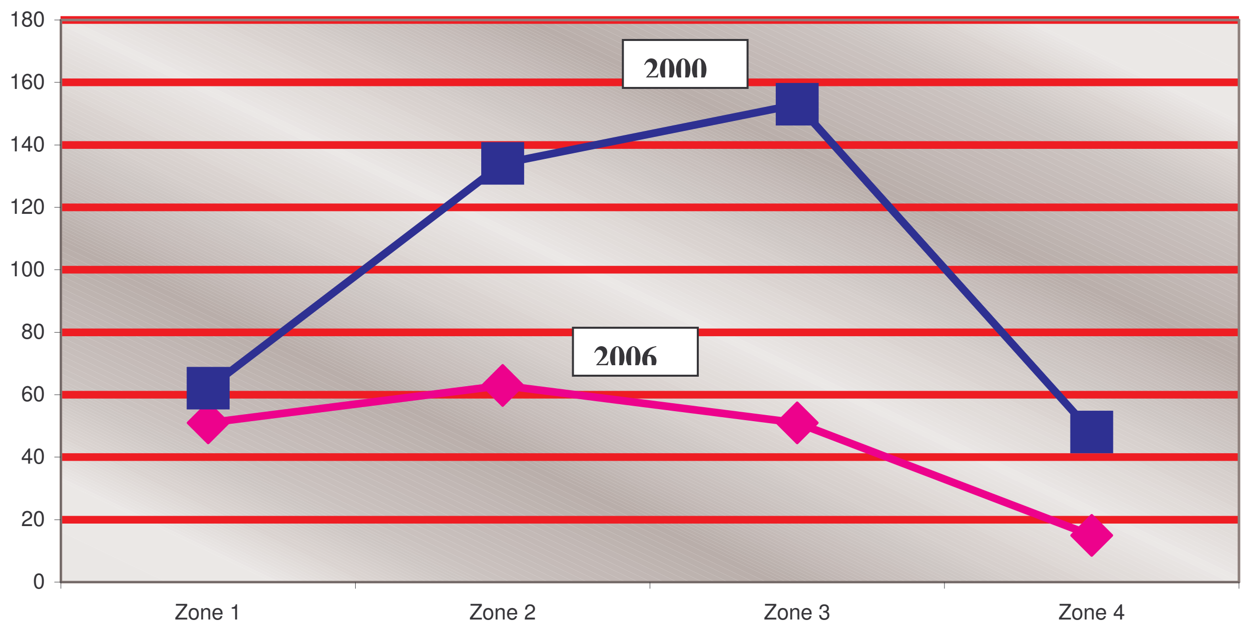


Chart 5: Zone Density



Species richness increased slightly between 2000 and 2006, with the biggest increase in richness found in Depth Zone 1 (0-1.5').

	2006	2000
Zone 1	3.19	2.42
Zone 2	2.3	2.6
Zone 3	3	3.57
Zone 4	1.5	2.08
Overall	2.86	2.73

THE COMMUNITY

The Simpson's Diversity Index for Lower Camelot Lake in 2006 was .87, a fair species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). This places it in the average range for Simpson's Diversity Index readings for both North Central Hardwood Forest and all Wisconsin lakes. However, this is lower than the Simpson's Diversity Index for 2000, which was .91. The 2006 and 2000 AMCI for Lower Camelot Lake were 53, placing the lake's AMCI in the average range for North Central Wisconsin Lakes and all Wisconsin Lakes.

Table 5: Aquatic Macrophyte Community Index-2006 & 2000

	2000 Result	2000 Value	2006 Result	2006 Value
Maximum Rooting Depth	13'	7	15.5'	9
% Littoral Zone Vegetated	86.30%	10	86.30%	10
% Submergent Species	82%	10	95%	7
% Sensitive Species	3%	4	11%	6
% Exotic Species	10%	5	10%	5
Taxa #	18	8	23	9
Simpson's Diversity Index	0.91	9	0.87	7
		53		53

Using the AMCI index, no significant overall change has occurred in the aquatic plant community in Lower Camelot Lake between 2000 and 2006.

The presence of several invasive, exotic species could be a significant factor in the future. Currently, none of the exotic species appear to be taking over the aquatic plant community, but *Myriophyllum spicatum* had an occurrence frequency over 24% and increased since 2000, despite the long history of both chemical and mechanical control efforts. This plant must continue to be monitored, since its tenacity and ability to spread to large areas fairly quickly could make them a danger to the diversity of Lower Camelot Lake's current aquatic plant community. Although no *Potamogeton crispus* was found in Lower Camelot Lake in 2006, it was found in the 2000 survey. Since the 2006 survey was conducted in August, it is possible that this lake still has *Potamogeton crispus* that had simply died off by then, since *P. crispus* tends to be an early-season plant. The lake should also be monitored for this invasive.

An Average Coefficient of Conservatism and a Floristic Index calculation were performed on the field results. Technically, the Average Coefficient of Conservatism measures the community's sensitivity to disturbance, while the Floristic Quality Index measures the community's closeness to an undisturbed condition. Indirectly, they measure past and/or current disturbance to the particular community.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat.   This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often rare, endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservatism in Lower Camelot Lake in 2006 was 4.4 and 3.69 in 2000. This puts this lake in the lowest quartile for Wisconsin Lakes (average 6.0) and for lakes in the North Central Hardwood Region (average 5.6). The aquatic plant community in Lower Camelot Lake is in the category of those lakes most tolerant of disturbance, probably due to selection by a series of past disturbances.

The Floristic Quality Index of the aquatic plant community in Lower Camelot Lake of 19.68 in 2006 and 16.5 in 2000 is below average for Wisconsin Lakes (average 22.2) and the North Central Hardwood Region (average 20.9). This suggests that the plant community in Lower Camelot Lake is farther from an undisturbed condition than the average lake in Wisconsin overall and in the North Central Hardwood Region. However, the Floristic Quality Index has increased between 2000 and 2006, suggesting some small progress in overall aquatic plant health may be occurring. Using either the Average Coefficient of Conservatism or the Floristic Quality Index scales, the aquatic plant community in Lower Camelot Lake apparently has been impacted by a more than average amount of disturbance.

"Disturbance" is a term that covers many disruptions to a natural community. It includes physical disturbances to plant beds such as boat traffic, plant harvesting, chemical treatments, dock and other structure placements, shoreline development and fluctuating water levels. Indirect disturbances like sedimentation, erosion, increased algal growth, and other water quality impacts will also negatively affect an aquatic plant community. Biological disturbances such as the introduction of non-native and/or invasive species (such as the Eurasian Watermilfoil, Reed Canarygrass and Curly-Leaf Pondweed found here), destruction of plant beds, or changes in aquatic wildlife can also negatively impact an aquatic plant community. Shore development and sediment deposition can also reduce the quality of the aquatic plant community.

Out of the 20 transects sampled on Camelot Lake, only one site was totally naturally vegetated. Therefore, no statistical evaluation comparing the aquatic macrophyte communities at disturbed vs. natural shores was appropriate.

IV. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Lower Camelot Lake is a eutrophic/mesotrophic impoundment with fair water clarity and fair to good water quality. This trophic state should support substantial plant growth and frequent algal blooms.

Sufficient nutrients (trophic state), fair water clarity, hard water, shallow lake, and heavy shore development at Lower Camelot Lake favor plant growth. Despite the sometime limiting effect of sand sediments on aquatic plant growth, 86% of the lake is vegetated, suggesting that even the heavily-sandy sediments in Lower Camelot Lake hold sufficient nutrients to maintain aquatic plant growth.

Historically, many aquatic plant treatments in Lower Camelot Lake were chemical. There has been mechanical harvesting to try to reduce plant growth in the last 10 years or so. A continued regular schedule and pattern of machine harvesting will help in removing vegetation from the lake and may help with nutrient reduction. The harvesting should also be designed to set back the growth of Eurasian Watermilfoil, not spread it further. It might also help to skim off the filamentous algae.

The lake has some mixture of plant structure that includes emergent, floating-leaf and submerged plants. However, the emergent and floating-leaf plants, which are important components of habitat, are very scarce in this lake. Of the 23 species found in Lower Camelot Lake, 21 were native and 2 were exotic invasives. In the native plant category, 8 were emergent, 1 was a floating-leaf plant, and 12 were submergent species. Notably, emergent plants continue to be scarce in this lake. Two exotic invasives, *Myriophyllum spicatum* (Eurasian Watermilfoil) and *Phalaris arundinacea* (Reed Canarygrass) were found.

Najas flexilis and *Vallisneria americana* were the most frequently-occurring plants in Lower Camelot Lake in 2006 (each with 46.58% frequency), closely followed by *Chara* spp at 42.47% occurrence frequency. No species reached a frequency of 50% or greater in the lake overall. When reviewing the frequency within the vegetated areas, only *Vallisneria americana* reached an occurrence frequency over 50%, and *Chara* spp was just under at 49.21%.

Vallisneria americana was also the densest plant in Lower Camelot Lake, with a mean density of 1.36 (on a scale of 1 to 4). In the lake overall, none of the aquatic vegetation had a mean density of over 2.0, meaning none occurred at more than average. There were no species at more than average density in Depth Zones 1, 2 and 4. Zone 3 had *Vallisneria americana* at 2.42 density. The densest-occurring plant in Depth Zone 1 (0-1.5') was *Najas flexilis* (1.3). Densest in Depth Zone 2 (1.5'-5.0') was *Chara* spp (1.91). In Depth Zone 4 (10'-20'), *Vallisneria americana* was densest, with an occurrence density of 1.14.

However, when looking at the "mean density where present", several plants had a more than average density of occurrence: *Najas flexilis; Potamogeton illinoensis; Potamogeton zosteriformis,* and *Vallisneria americana.* All of these plants are submergent plants. These figures indicate that where these species occurred, they exhibited a growth form of above average density and could interfere with fish habitat and recreational use.

The very few shoreline areas of native vegetation and wetlands on the lake should be preserved as they are to maintain habitat and to serve as a buffer for that area. Studies have suggested that runoff from natural shores is substantially less than that of developed areas. On the disturbed shores, there are some areas of deep erosion on steep banks that need to be addressed to prevent tree fall (and related root ball removal from bank) and bank preservation. Shoreline restoration of native vegetation is badly needed on Lower Camelot Lake.

The Simpson's Diversity Index for Lower Camelot Lake in 2006 was .87, an indication of fair species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). This places it in average range for Simpson's Diversity Index readings for both North Central Hardwood Forest and all Wisconsin lakes. The AMCI for Lower Camelot Lake is 53, placing it in the low average range for North Central Wisconsin Lakes and all Wisconsin Lakes.

Some type of native vegetated shoreline covered only 23.0% of the lake shoreline. Naturally-occurring rock covered 2.5% of the shore. Disturbed shorelines---including bare sand, traditional cultivated lawn, hard structure (piers, decks, seawalls, etc.) and rock riprap---were the most frequently-occurring shore, with each occurring with 55% to 65% frequency. Overall, they covered 77.0% of the shore of Lower Camelot Lake. These conditions offer little protection for water quality and have significant potential to negatively impact Lower Camelot Lake's water by increased runoff (including lawn fertilizers, pet waste, pesticides) and shore erosion.

Looking at the results from the 2000 survey and those from 2006 shows some changes in the aquatic plant community, not necessarily for the better. Although there were slightly more species found in 2006, the structure of the aquatic plant community has become more unbalanced, shifting to even more submergent vegetation, with fewer emergent, floating-leaf and free floating aquatic plants. Although species richness, the Floristic Quality Index, the Average Coefficient of Conservatism, and the AMCI has stayed close in value, these values are still below or barely at average.

Lower Camelot	2000	2006	Change	%Change
Number of Species	18	23	2	**27.8%**
Maximum Rooting Depth in Feet	13.0	15.5	3	**19.2%**
% of Littoral Zone Unvegetated	13.7%	13.7%	0.0%	0.0%
%Sites/Emergents	11.63%	4.44%	-0.1	-61.8%
%Sites/Free-floating	6.50%	0.00%	-0.1	-100.0%
%Sites/Submergents	81.97%	95.58%	0.1	16.6%
%Sites/Floating-leaf	9.00%	1.00%	-0.1	-88.9%
Simpson's Diversity Index	0.91	0.87	-0.04	-4.4%
Species Richness	2.73	2.86	0.13	**4.8%**
Floristic Quality	16.50	19.68	3.18	**19.3%**
Average Coefficient of Conservatism	3.89	4.4	0.51	**13.1%**
AMCI Index	53	53	0	0%

Changes in the Aquatic Plant Community 2000 to 2006

Further, when calculating the Coefficient of Similarity between the 2000 and 2006 surveys, they score as statistically dissimilar. Based on frequency of occurrence and relative frequency, the aquatic plant communities of the two years are only 65% similar. Similarity percentages of 75% or more are considered statistically similar; obviously, Lower Camelot Lake percentages are far from that.

It is worth noting that the report on the 2000 aquatic plant surveys mentioned the absence of emergent plants in Lower Camelot Lake. The 2006 survey shows that emergent plants are even more scarce in Lower Camelot Lake than they were in 2000. *Vallisneria americana*, which is encouraged by harvesting, has increased in frequency and density two to three fold. *Najas flexilis*, a disturbance indicator, has more than doubled.

	Changes in Aquatic Plant Species				
Lower Camelot					
Species		2000	2006	Change	%
				2000-2006	Change
Ceratophyllum demersum	Frequency	0.11	0.05	-0.06	-54.5%
	Mean Density	0.66	0.22	-0.44	-66.7%
	Dom. Value	0.23	0.09	-0.14	-60.9%
Chara spp	Frequency	0.19	0.17	-0.02	-10.5%
	Mean Density	1.47	0.84	-0.63	-42.9%
	Dom. Value	0.46	0.34	-0.12	-26.1%
Elodea canadensis	Frequency	0.03	0.02	-0.01	-33.3%
	Mean Density	0.11	0.07	-0.04	-36.4%
	Dom. Value	0.05	0.03	-0.02	-40.0%
Myriophyllum spicatum	Frequency	0.08	0.10	0.02	25.0%
	Mean Density	0.29	0.36	0.07	24.1%
	Dom. Value	0.13	0.17	0.04	30.8%
Najas flexilis	Frequency	0.08	0.19	0.11	137.5%
	Density	0.49	1.07	0.58	118.4%
	Imp. Val.	0.17	0.4	0.23	135.3%
Potamogeton foliosus	Frequency	0.03	0.02	-0.01	-33.3%
	Density	0.08	0.04	-0.04	-50.0%
	Imp. Val.	0.04	0.02	-0.02	-50.0%
Potamogeton pectinatus	Frequency	0.11	0.07	-0.04	-36.4%
	Density	0.6	0.25	-0.35	-58.3%
	Imp. Val.	0.22	0.12	-0.1	-45.5%

Potamogeton pusillus	Frequency	0.07	0.06	-0.01	-14.3%
	Density	0.37	0.08	-0.29	-78.4%
	Imp. Val.	0.14	0.07	-0.07	-50.0%
Sagittaria latifolia	Frequency	0.01	0.01	0	0.0%
	Density	0.03	0.12	0.09	300.0%
	Imp. Val.	0.02	0.03	0.01	50.0%
Scirpus validus	Frequency	0.01	0.01	0	0.0%
	Density	0.04	0.01	-0.03	-75.0%
	Imp. Val.	0.02	0.01	-0.01	-50.0%
Typha angustifolia	Frequency	0.01	0.01	0	0.0%
	Density	0.05	0.04	-0.01	-20.0%
	Imp. Val.	0.02	0.02	0	0.0%
Vallisnera americana	Frequency	0.06	0.19	0.13	216.7%
	Density	0.32	1.36	1.04	325.0%
	Imp. Val.	0.12	0.46	0.34	283.3%
Zosterella dubia	Frequency	0.03	0.02	-0.01	-33.3%
	Density	0.08	1.36	1.28	1600.0%
	Imp. Val.	0.04	0.03	-0.01	-25.0%

V. CONCLUSIONS

Lower Camelot Lake is a eutrophic to mesotrophic impoundment with fair to good water quality and water clarity. The Average Coefficient of Conservatism average of the aquatic plant community in Lower Camelot Lake is below average for Wisconsin lakes and for lakes in the North Central Hardwood region, as is the Floristic Quality Index, indicating the plant community has been impacted by an above average amount of disturbance. The AMCI is in the average range for both North Central Hardwood Region and all Wisconsin lakes. Filamentous algae are present. Structurally, the aquatic plant community contains very few emergent plants or floating-leaf rooted plants and no floating plants. Submergent plants dominate the aquatic plant community in this lake.

Both in 2000 and 2006, over 86% of the littoral zone was vegetated. The potential for plant growth at all depths of the lake is present, even with many of the lake sediments sandy. This growth percent is close to the maximum recommended vegetation percentage for best fishing (50%-85%).

Najas flexilis and *Vallisneria americana* were the most frequently-occurring plants in Lower Camelot Lake in 2006 (each with 46.58% frequency), closely followed by *Chara* spp at 42.47% occurrence frequency. No species reached a frequency of 50% or greater in the lake overall. When reviewing the occurrence frequency within vegetated areas, only *Vallisneria americana* reached an occurrence frequency over 50%, and *Chara* spp was just under at 49.21%.

A healthy and diverse aquatic plant community plays a vital role within the lake ecosystem. Plants help improve water quality by trapping nutrients, debris and pollutants in the water body; by absorbing and/or breaking down some pollutants; by reducing shore erosion by decreasing wave action and stabilizing shorelines and lake bottoms; and by tying-up nutrients that would otherwise be available for algae blooms. Aquatic plants provide valuable habitat resources for fish and wildlife, often being the base level for the multi-level food chain in the lake ecosystem, and also produce oxygen needed by animals.

Further, a healthy and diverse aquatic plant community can better resist the invasion of species (native and non-native) that might otherwise "take over" and create a lower quality aquatic plant community. A well-established and diverse plant community of natives can help check the growth of more tolerant (and less desirable) plants that would otherwise crowd out some of the more sensitive species, thus reducing diversity.

Vegetated lake bottoms support larger and more diverse invertebrate populations that in turn support larger and more diverse fish and wildlife populations (Engel, 1985). Also, a mixed stand of aquatic macrophytes (plants) supports 3 to 8 times more invertebrates and fish than do monocultural stands (Engel, 1990). A diverse plant community creates more microhabitats for the preferences of more species.

MANAGEMENT RECOMMENDATIONS

(1) Because the plant cover in the littoral zone of Lower Camelot Lake is close to the maximum coverage recommended (25%-85%) for balanced fishery and there are some areas with more than average plant density, continued harvesting to open fishing lanes should occur in some areas, following the harvesting plan outlined in the Lake Management Plan. Removal should occur by hand in the shallower areas to be sure that entire plants are removed and to minimize the amount of disturbance to the sediment.

(2) Natural shoreline restoration and erosion control in many areas is needed, especially on some bare steep banks. If trees fall at the eroded sites due to continued erosion, large portions of the banks will fall with them.

(3) To protect banks and water quality, a buffer area of native plants needs to be restored on those many sites that now have seawalls or have traditional lawns mowed to the water's edge. Large areas of the lake shoreline are unnatural

and prone to erosion & runoff of nutrients & toxics. Unmowed native vegetation reduces runoff into the lake and filters runoff that enters the lake.

(4) The Tri-Lakes Management District and the Camelot Lake Association should continue to cooperate with the WDNR for zebra mussel invasion in the Tri-lakes system.

(5) Stormwater management of the many impervious surfaces around the lake is essential to maintain the current quality of the lake water and prevent further degradation. This is especially important since studies show that nutrients in the Tri-Lakes system are coming from the shores within the lakes.

(6) No lawn chemicals should be used on properties around the lake. If they must be used, they should be used no closer than 50' to the shore.

(7) The aquatic plant management plan should be reviewed annually. Mechanical harvesting plans should continue target harvesting for Eurasian Watermilfoil (EWM) and include target harvesting for Curly-Lead Pondweed to prevent further spread.

(8) The Camelot Lake Association may want to continue to apply for grants from the Wisconsin Department of Natural Resources to help defray the cost of aquatic plant management.

(9) No broad-scale chemical treatments of aquatic plant growth are recommended due to the undesirable side-effects of such treatments, including increased nutrients from decaying plant material and decreased dissolved oxygen and opening up more areas to the invasion of EWM.

(10) Any fallen trees should be left at the shoreline or in the water for fish and wildlife habitat.

(11) The Tri-Lakes Management District conducted water quality monitoring for several years, but has decreased its involvement during 2004-2006 when Adams Land & Water Conservation Department was doing more intense

monitoring as part of a Lake Classification Grant. Monitoring by the Lake District or through the DNR Self-Help Monitoring Program should be restarted.

(12) Lower Camelot Lake residents should identify, cooperate with and participate in watershed programs that will reduce nutrient and sediment inputs.

(13) No drawdowns of water level except for DNR-approved purposes should occur. Several of the plants found in Lower Camelot Lake in 2006 are those encouraged by drawdowns.

(14) The few sites where there is undisturbed shore should be maintained and left undisturbed.

(15) The Tri-Lakes Management District should make sure that its lake management plan takes into account all inputs from both the Lower Camelot Lake surface ground watershed and inputs from Camelot & Sherwood Lakes, and addresses the concerns of this larger lake community.

(16) Cooperation with the Adams County Parks Department in keeping the boat ramp area in safe condition should help reduce any negative impacts caused by the heavy use of this public area.

(17) Pursue installation of sewage system around the lake to reduce nutrient input from the lakeshores. Reducing nutrient inputs by residents needs to occur before asking watershed residents to reduce theirs.

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